DESIGN OF THE GREAT LAKES OBSERVING SYSTEM ENTERPRISE ARCHITECTURE

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Abstract

A comprehensive, collaborative, and consensus-based enterprise architecture design process was conducted under the direction of NOAA-Great Lakes Environmental Research Laboratory (GLERL). The project brought together multi-disciplinary experts to identify and recommend specific actions and investments for the next five years that will achieve an integrated, comprehensive, and sustainable observing system enterprise for the Great Lakes. The enterprise system—a highly-leveraged evolution of existing resources—will provide ready access to vital real-time and historical information to support decision-making by managers and users of this unique and invaluable resource.

Key words: observing systems, Great Lakes, DMAC, enterprise architecture

1. INTRODUCTION AND PURPOSE OF THE DESIGN STUDY

A comprehensive, collaborative, and consensus-based enterprise architecture design process for the Great Lakes Observing System was conducted under the direction of NOAA-Great Lakes Environmental Research Laboratory (GLERL). The project brought together multi-disciplinary experts to identify and recommend specific actions and investments for the next five years that will achieve an integrated, comprehensive, and sustainable observing system enterprise for the Great Lakes. This Great Lakes Observing System Enterprise—a highly-leveraged evolution of existing resources—will provide ready access to vital real-time and historical information to support decision-making by managers and users of this unique and invaluable resource.

1.1. Origins and Design Partners

In 2010, the NOAA GLERL received funding under the Great Lakes Restoration Initiative to develop a near term design for the Great Lakes Observing System (GLOS) Enterprise Architecture. The GLOS Enterprise will be an integrated, holistic ecosystem observing system that will include the physical, chemical, and biological data collection and observation necessary to support effective Great Lakes management. The enterprise system will also be equipped to detect change in the Great Lakes coastal environment resulting from the basin-wide implementation of the Great Lakes Restoration Initiative (GLRI, 2010). Design documents developed under the project present a strategic plan for the near term development of the GLOS enterprise (LimnoTech, 2011). The strategic plan is intended to leverage and build on the foundation of the existing programs and initiatives of GLOS, IOOS, NOAA-GLERL, and the GLRI.

The project was conducted by LimnoTech with assistance from Applied Science Associates, the Michigan Tech Research Institute (MTRI), Clarkson University and the University of Minnesota – Duluth. The sponsoring agency was the NOAA GLERL lab, and key partners included the Great Lakes Observing System Regional Association (GLOS RA), the USGS, the USEPA (Great Lakes National Program Office), and an extensive Expert Advisory Panel acknowledged at the end of this paper.

1.2. Elements of the Enterprise System

The Great Lakes Observing System Enterprise, like others around the world, is a complex and interwoven enterprise system that comprises: equipment, software, data and processed information; the people who use, maintain and manage the system; and the governmental, academic, and private entities that interact with and develop the system. The collection of all of these elements into a single, multidisciplinary enterprise is depicted in Figure 1, which illustrates how sensing observations are ultimately translated into data and information products required by a broad array of users.

A critical goal of this project's conceptual design effort was to describe the first steps required in taking the existing observing system elements to an integrated whole, or enterprise. The data management and communications system (DMAC) at the core of the observing system enterprise provides a way to take available sensed information, bring it to where it needs to be, use it to make short-term decisions, store and

draw on historical information to make knowledgeable long-term decisions, and communicate information to others.

The Great Lakes Observing System Enterprise also provides an organizational framework for the interactions of this user community and high level research and operational users who interact to build, maintain and use the system collaboratively (Figure 2). GLOS, the nonprofit Regional Association of IOOS, plays a central role in public outreach and data coordination for the system as a whole, and the Federal agencies are also central in pursuing complementary management and scientific missions in the Great Lakes.

1.3. Environmental, Social, and Economic Drivers of the Observing System

The development of a Great Lakes Observing System Enterprise presents a compelling opportunity to address the intertwined drivers of value in the Great Lakes region: environmental (particularly water) resources, and economics. The Great Lakes-St. Lawrence Region contains vast environmental, social and economic resources. As the Great Lakes community has moved toward an Ecosystem Approach for stewardship of the basin, economic and environmental issues are increasingly viewed as complementary rather than conflicting concerns. The Great Lakes Observing System Enterprise provides a clear opportunity to address environmental issues while also stimulating the regional economy; in short, it will transform the way that we interact with and manage the irreplaceable Great Lakes ecosystem.

2. SUMMARY OF USER NEEDS

Many important elements of the Great Lakes Observing System Enterprise are in place and are already routinely being used by informed users to make decisions. We therefore have a good indication of who the users currently are, and an indication of the current value of information provided. We also have information on the "market potential," future growth of the user community, and potential value that could be realized by building a fully integrated and easily accessible observing system. In addition, we expect new users to emerge and value to be created beyond those presently imagined. As the DMAC of the Great Lakes Observing System Regional Association becomes fully functional, the information will be readily accessible to many. As additional users become aware of the system's capabilities, the uses and resulting value will increase exponentially. All told, economists conservatively estimate that investments in better observations in the Great Lakes could provide at least $100 million in economic returns per year. Some examples of the user community follow:

Shipping – Great Lakes shipping is a $3.5 billion industry that provides cost-effective and virtually irreplaceable transportation of bulk cargo between Great Lakes and international ports.

Recreational Boating and Fishing – As of 2010, there are 4.2 million recreational boats registered in the eight Great Lakes states, which is about 1/3 of all boats registered in the U.S.

Municipal Water Suppliers - 40 million people in the U.S. and Canada get their drinking water from the fresh waters of the Great Lakes.

Emergency Response Teams – District 9 of the U.S. Coast Guard (Great Lakes Region) routinely dispatches 5,000-7,000 sorties annually, saving 300-600 lives per year, with 50-100 lives lost.

Fisheries Managers – The Great Lakes support a multi-billion dollar fishery.

Beach Managers and Users – Millions of residents and visitors swim, surf, and recreate at Great Lakes beaches.

Industries - There are approximately 90 U.S. power plants located on the shores of the Great Lakes that use the vast supplies of water for cooling and steam generation.

Great Lakes Ecosystem Scientists and Managers – Numerous U.S. and Canadian bi-national, federal, state/provincial, regional and local agencies, industries, academic institutions and watershed groups play important roles in the restoration, protection, and stewardship of the Great Lakes ecosystem.

The coordinated efforts of these large and diverse user groups would benefit greatly from a "one stop shop" – a fully capable and integrated Great Lakes observing system. The system would open up access to information, increase transparency and accountability of agency programs, foster inter-agency collaboration, and ultimately result in greater overall productivity and efficiency and elimination of redundancies.

3. STATE OF THE OBSERVING SYSTEM AND TECHNOLOGY

It is important to note that the Great Lakes Observing System Enterprise does not need to be designed and built from scratch; many of the elements and functions already exist and some are in operation. Extensive work has been conducted over the past two decades by various agencies and institutions that provide many of the components necessary for an operational Great Lakes Observing System Enterprise. However, the data from these elements are distributed among hundreds of agency departments and institutions, with only some of the data readily available through independent and largely unconnected websites. Accessing the available

information currently requires that users possess intimate experience, knowledge, luck, and/or time to spend hours and days on Internet searches. A centralized data management and communications system for the enterprise, while initiated in important fragments by different agencies, has not yet been fully built and integrated; sensors for the suite of important data have not yet been fully deployed; and feedback connections among users and providers are lacking. But given those pieces that are in place, the time is right for smart investments to build the connections and to begin filling in the missing pieces.

Many of the elements that are necessary for a fully capable Great Lakes Observing System Enterprise are in place, but have not yet been integrated into a fully functioning observing system. Some elements currently in operation include:

Strong Existing Interagency Cooperation and Collaboration – Perhaps the most important element established over the past several years are the collaborative relationships that have developed between people in key federal agencies in the US and Canada for sharing information and aligning missions. Key agency departments include NOAA – IOOS, NOAA – National Data Buoy Center, NOAA – National Weather Service, NOAA – GLERL, USEPA – Great Lakes National Program Office, USEPA – Region 5, USEPA-Office of Research and Development, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, US Geological Survey, Environment Canada, International Joint Commission, Great Lakes Fishery Commission, Great Lakes Commission, Ocean Policy Council, NASA, and all of the State and Provincial Environmental and Natural Resource agencies in the basin.

An Existing System of Sensors and Data Collection – Various agencies are already conducting much of the sensing and data collection necessary to support an observing system. For example, 22 buoys, providing real time meteorological and physical lake data are routinely deployed throughout the Great Lakes by the National Data Buoy Center in cooperation with the U.S. Coast Guard and by Environment Canada. In addition, the network of buoys deployed by others (GLOS, GLERL, coastal cities, academic institutions, and industries) that upload data to the NDBC is continuing to expand. NOAA and Environment Canada maintain 96 lake level stations, and 97 fixed shore based meteorological stations. Remote sensors on NASA and NOAA satellites provide invaluable information on land and surface waters in the Great Lakes basin. Routine cruise sampling using conventional sampling methods and towed sensor arrays is conducted by the USEPA and NOAA monitoring and research vessels, the Lake Guardian and the Laurentian, respectively. There are over 100 other science vessels that regularly ply the

waters of the Great Lakes (http://www.canamglass.org/dev/index.php). The USGS maintains an extensive Water Quality Monitoring Network. Vast amounts of useful and relevant data have been and are continuing to be collected by others (e.g. municipal water suppliers, academic institutions, beach managers, local public health departments, State agencies, the Integrated Air Deposition Network., etc.).

A Scientifically Based Set of Operational and Near-Operational Models – There has been significant model development conducted in the Great Lakes over the past 40 years. Some models developed by NOAA are already operational and provide now casts and forecasts and are accessible on various web-sites (e.g. NOS and NWS meteorological and Great Lakes forecasting models, NOAA and USGS water level forecasting models), and other models are near operational, providing provisional real time forecasts such as the NOAA-GLERL Great Lakes Coastal Forecasting models and the Huron-Erie corridor hydrodynamic model. In addition there are a host of Great Lakes models that have been developed for research and management purposes and could become operational without starting from scratch (e.g. Lake Michigan Mass Balance Model, Saginaw Bay and Maumee Bay linked hydrodynamic ecosystem models, etc.).

Existing Programs: The agency programs, departments and partnerships necessary to support the Great Lakes observing system are already established and functioning, including, GLOS, NDBC, NOAA-GLERL sensing and forecasting, Great Lakes Beaches Program, USGS WQ Network, NOAA and NASA satellite imagery programs, regular Great Lakes environmental monitoring by EPA and Environment Canada, the State of the Lakes Ecosystem Conference (SOLEC), the binational Cooperative Science and Monitoring Initiative (CSMI), the International Joint Commission, and all of the accountability aspects of the Great Lakes Restoration Initiative (GLRI).

4. DESIGN APPROACHES AND FINDINGS

4.1. Federal Enterprise Architecture Methodology
The enterprise architecture design approach employed built on the existing GLOS RA conceptual plan, and was modeled to reflect IOOS guidance on component architectures and to include key steps laid out in the Federal Segment Architecture Methodology.

The design balanced user needs, the state of Great Lakes science, modeling, and observation technology; DMAC needs and capabilities, operation and maintenance requirements, risk assessment and mitigation, and business options, including capital and operational life-cycle costs and schedules for construction and implementation risk assessment. The balance was

informed by detailed trade study considerations of these factors and delivered a range of optimized and sustainable mixes of sensors, infrastructure, and analysis that best met the user needs cataloged in this study.

4.2. Identified Design Drivers and Opportunities

User Needs and Observing System Enterprise Elements Necessary to Address Those Needs Vary by Scale – Some user needs are common across the entire Great Lakes basin, other needs are specific to each individual lake or connecting channel, and others are more local and should be addressed through regional scale observing system elements. The design and implementation of the GLOS Enterprise will be best accomplished considering these different scales, and providing flexibility in the DMAC to handle the variety of data at all scales. Funding approaches, timing, and phasing of the build out will also likely be different for these different scales, as described below:

Basin-wide User Needs – Ecosystem resource managers, global climate change scientists, and the national weather service depend on data collected from stations across the basin. Conditions such as water levels, ice cover distribution and duration, water temperature, basin water balance, total area and distribution of wetlands, air deposition of contaminants, etc., will require basin-wide sensing.

Lake-wide User Needs – Fisheries and lake scientists and ecosystem resource managers need information on issues that are specific to each lake. Existing and potential stressors and issues in Lake Superior, for example, are different than those in other lakes. The design of the sensing and forecasting systems to address lake-wide issues may be different for each lake, and may be different from, but draw on the basin wide and regional scale sensing networks.

Regional Scale User Needs – The potential for deadly rip currents, bacteria contamination of water supplies or beaches, harmful and nuisance algal blooms, zones of hypoxia, chemical spills, coastal erosion, or other issues will vary by locality. Sensing and sampling designs for monitoring issues important to specific regions will need to be developed on a region by region basis. Similarly, the build out of regional observing elements will likely be best driven by the local communities.

User Needs and Observing Elements Necessary to Address Those Needs Vary by Time. Some users will need instant access to real-time information such as weather, wave, and hydrodynamic now casts and forecasts. Other users will be interested in data collected and reported on a daily, monthly or annual basis. Other users such as resource scientists and managers will be interested in data to determine long-term trends. The observing system will need to be flexible to accommodate the collection, compilation, analysis, storage and communication across these different time scales.

Data Management and Communications Are Critical. There is a significant identified need for a Great Lakes basin-wide DMAC to serve as a community base for gathering and disseminating of sensing data, and making data available for use by the both the modeling and end-user communities. The DMAC needs to be interoperable with IOOS and GEOSS, so coordination efforts such as the GEOSS test bed project and IOOS participation should continue.

Existing Remote Sensing Capabilities Present Significant Opportunities. Significant advances have been made and are being made in the area of satellite based remote sensing, and the observing system should be positioned to respond effectively to these opportunities. There is a gap in the current ability of researchers and users across the system to access and benefit from remote sensing data, and also a gap in the availability of tools and algorithms to process the data. Filling these gaps should be a priority. The investments that have been made by NOAA and NASA in satellite infrastructure and operations should be fully leveraged to maximize the value of the sensing data to address monitoring needs for the Great Lakes.

Existing Models Present Significant Opportunities. Models are central to the operation of the Great Lakes observing system enterprise, and there are significant opportunities to be gained from the widespread dissemination and use of these models. There is a great wealth of model development and application throughout the Great Lakes Basin and for a wide range of environmental issues and user needs. Some of those models are largely research focused while others are more management focused. A concerted effort is needed to move models that serve user needs at all scales to an operational status within the enterprise. The enterprise design report makes recommendations for proceeding along this path.

5. PLANNING FOR IMPLEMENTATION: THE NEXT 5-20 YEARS

The implementation of the GLOS Enterprise has already been initiated with this project, and a series of steps that structure the implementation are described below and presented in Table 1 below. The table summarizes tasks that follow different timelines for completion, including tasks that will be substantially complete with the close of this project, shown in green. Tasks that are planned for completion within the 5-year timeframe of the near-term design are shown in blue, and tasks that are initiated during the 5-year timeframe but have a longer

schedule for completion are shown in orange. The major tasks are summarized as follows:

Step 0: Catalogue existing systems and build the geospatial database of observing systems for the DMAC. Under this task, a complete inventory of existing sensing systems and descriptions of monitored parameters, frequency and spatial locations is gathered for all systems in the Great Lakes.

Step A1: Catalogue and monitor completion of "Level A" activities. Under this task, the team lead will identify and monitor the completion of ongoing projects or readily accomplished projects that have existing planning and funding mechanisms in place, across the basin and at all regional, lake, and basin scales.

Step A2: Plan and build the DMAC. Under this task, a detailed design will be developed for the DMAC system to support all scales of observation across the basin, followed by a period of construction and then maintenance of the DMAC. The DMAC design will be basin scale in extent but will explicitly include functional capability to accommodate sensing system input and user interactions at the lake and regional scales.

Step A3: Design a Level A Sensing Strategy and implement at the Basin Scale, in Lake Michigan, and regionally on an opportunistic basis. Under this task, the Level A sensing strategy will be designed in detail and implemented across the Great Lakes, bringing the system to a baseline level of capability across the basin.

Step A4: Develop a plan for operationalizing models, and implement at the basin scale, in Lake Michigan, and regionally on an opportunistic basis. Under this task, a plan for operationalizing models will be developed in detail and implemented to different degrees at the basin, lake and regional scale.

Step B1: Develop a set of targeted expansion alternatives, and plans for implementation. The Level A design activities described above set the stage for expansion alternatives that target specific user needs and management issues with diverse objectives and funding strategies. We recommend that the implementation effort start with an intentional process of opportunity identification and prioritization, and then target 2-3 Observing System subarea projects for implementation over the 5-year near-term design period.

6. CONCLUSIONS AND OUTCOMES

As the GLOS enterprise architecture is implemented, data collected throughout the Great Lakes Basin will become more readily available to scientific researchers, resource management decision-makers, and to the general public. These data will support characterization of the state of the Great Lakes and the contributing watershed, allowing assessment of progress towards restoration goals.

The GLOS RA is currently constructing the integrated Great Lakes DMAC. Once constructed and the sensing system is more fully populated, and as the broader Great Lakes community becomes aware, the utility of the information will likely spawn new products, revenue, and jobs. From useful mobile applications for beach-goers, sailors and fishermen, to energy optimization products for power companies, to new sensor technologies, the GLOS Enterprise will seed innovation and entrepreneurship.

Economic studies have indicated that improvements in observations in the Great Lakes will save lives each year and create value on the order of tens to hundreds of millions of dollars per year. However, investments will be necessary to achieve these gains. Given the value that the data provide to certain users, such as power companies, coastal communities, recreational boaters, significant investment is already underway by entities other than the Federal government. The system has already and likely will continue to encourage co-investments from municipalities, Areas of Concern, user groups, private industry, and the States and Provinces that make up the Great Lakes community.

The lakes are a powerful economic engine for the region, and the restoration and caretaking of this resource has the potential to create businesses and jobs throughout the observing system enterprise. The observing system in the Great Lakes has the potential to provide a framework for environmental stewardship, investment, and economic activity that aligns economic and environmental goals for the region creating the right kind of jobs for a new economy of the Great Lakes.

References:

GLRI, 2010. *Great Lakes Restoration Initiative Action Plan, FY2010 - FY2014*.
http://greatlakesrestoration.us/pdfs/glri_actionplan.pdf

LimnoTech, 2011. *Design Report: Near-Term Design of the Great Lakes Observing System Enterprise Architecture.*
Prepared for NOAA-GLERL under Contract No. WC133R-10-CN-0350.
http://www.glos.us/sites/default/files/documents/%21GLOSEA_design_document_final.pdf

Integrated Technology / Data / Applications Architecture
IOOS Framework: Rapid Access to Diverse Data from Many Sources

Observations → Data Telemetry → Data Mgmt and Communications → Modeling and Analysis → Data / Information Products and Services

- Satellites
- Aircraft
- Fixed Platforms
- Ships
- Drifters and Floats
- AUVs

DMAC

Metadata standards

Data discovery

Data transport

Online browsing

Data Archival

- Maritime Navigational Services
- Search and Rescue
- Coastal Flooding and Erosion
- Beach Closures
- Water Management
- Management of Nutrient Loading
- Fisheries Management

Enterprise Architecture Framework
Technology Architecture → Data Architecture → Applications Architecture
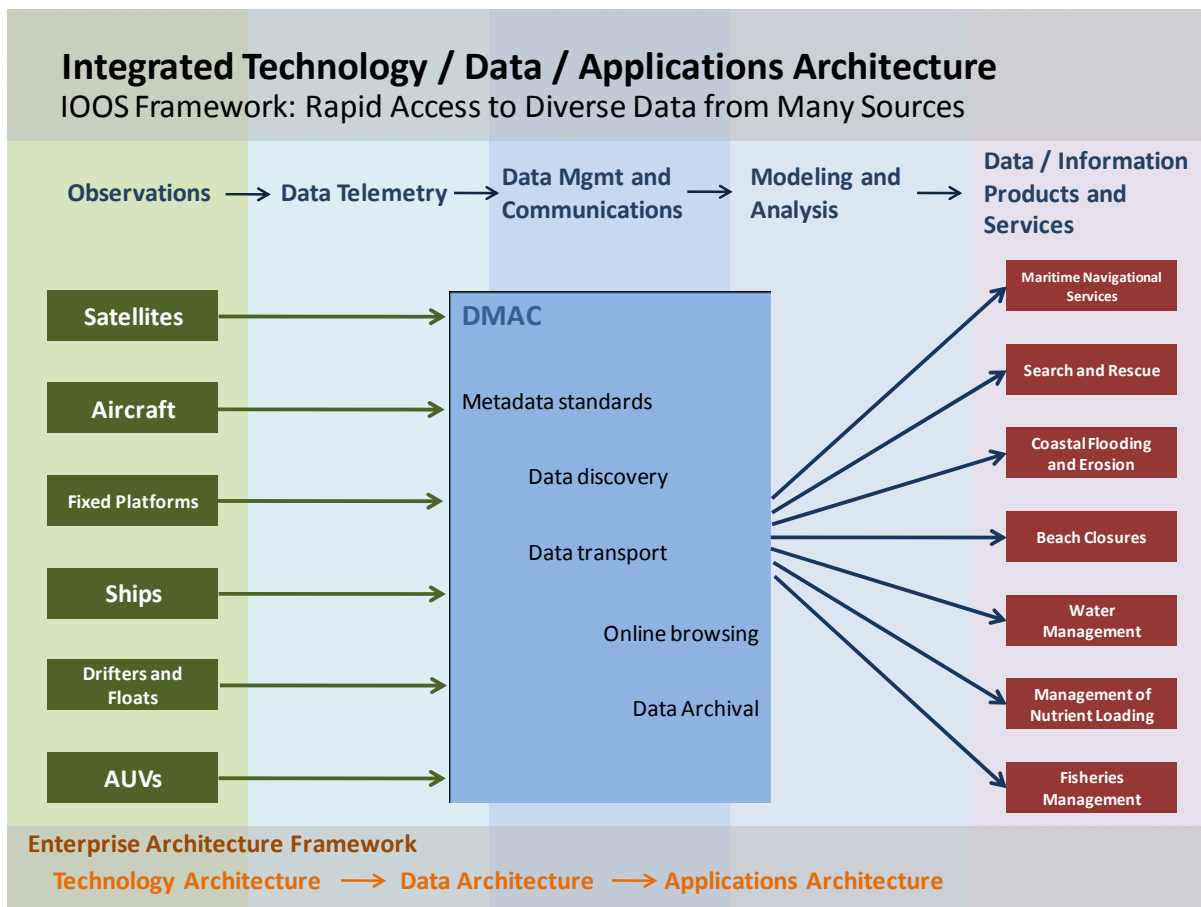
Figure 1: Elements of the Great Lakes Observing System Enterprise (Adapted from IOOS)
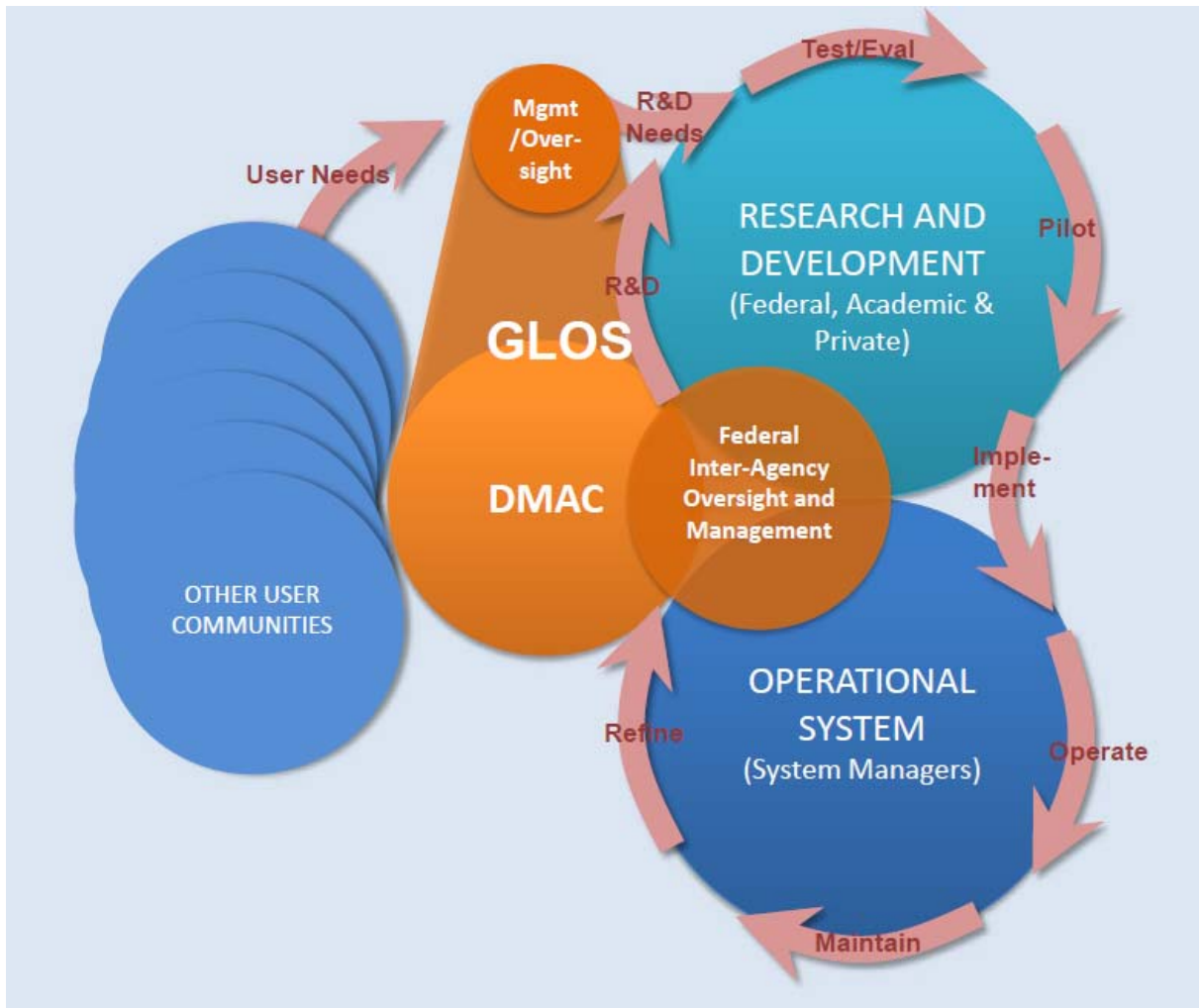
Figure 2: System Management, Development, and User Framework for the GLOS Enterprise

Table 1: Recommended 5-Year Planning Steps

Design Level	Implementation Level	Basin Scale	Lake Scale	Regional Scale
0	Step 0: Catalog existing systems and build the geospatial database of observing systems for the DMAC	Catalog is complete with this project, geospatial database initiated	Catalog is complete with this project, geospatial database initiated	Catalog is complete for RDAs, with this project geospatial database initiated
A	Step A1:Catalog ongoing or funding-in-place activities	Catalog is complete with this project; monitor through 2013	Catalog is complete with this project; monitor through 2013	Expand catalog to include all regional-scale activities; monitor through 2012
	Step A2: Plan and construct basin-wide DMAC	Within 5 years: Plan and build out DMAC to serve all scales of observation		
	Step 3A: Design and to the extent possible, implement a Level A sensing strategy	Design and implement minimum level of sensing at the basin scale	Design and implement minimum level of sensing in Lake Michigan, coordinated with CSMI activities	Develop a 5-year plan for minimum sensing in regional observing system subareas
	Step 4A: Develop and where possible, operationalize models required for each subarea (unique to each GLOS subarea)	Plan and operationalize basin-scale models, incorporating remotely sensed data	Operationalize Lake Michigan models, develop plan in 5 years to operationalize key models at the lake scale	Use lake-scale plan to inform plan for opportunistically operationalizing regional models
B	Step B1: Develop a set of targeted expansion alternatives, and plans for implementation	Within 5 years: Gather and prioritize user need -based drivers that will govern observing system expansion alternatives at the basin, lake, and regional scales		

- ● Substantially complete within this project
- ● Substantially complete within 5 years
- ● Develop groundwork within 5 years, complete in 10-20 years

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